Validation of AIRS over the Antarctic Plateau:
Low radiance, low humidity, and thin clouds

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The Validation Concept

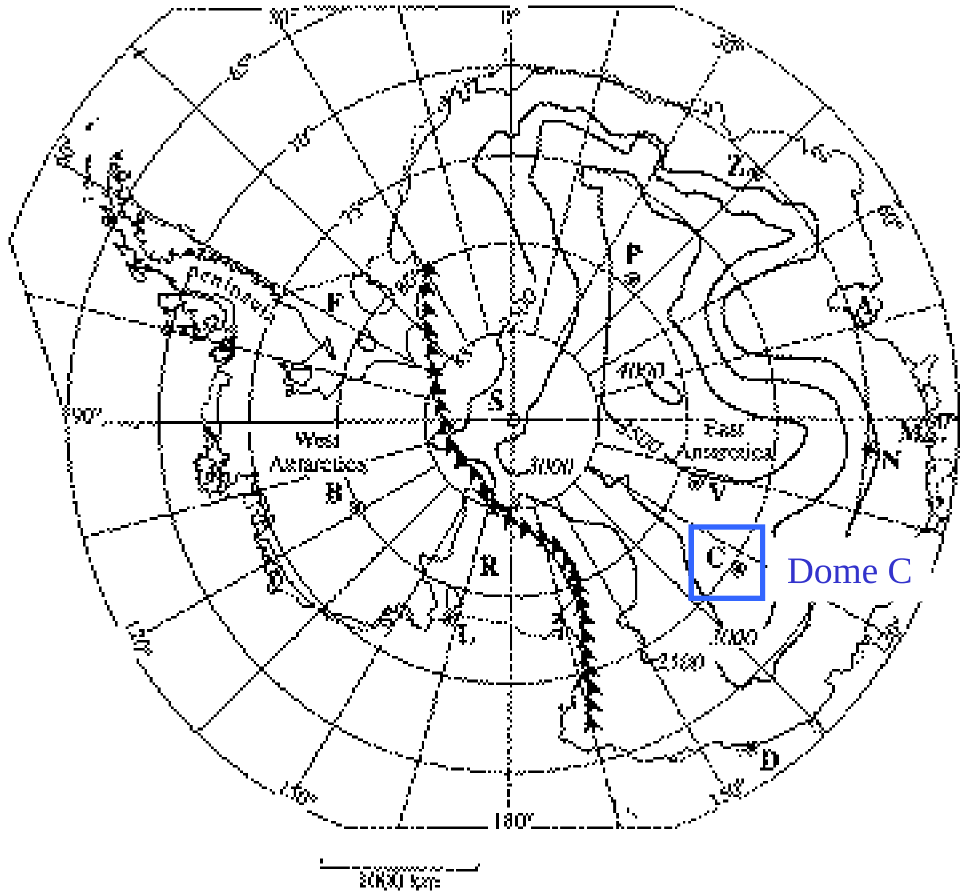
- Use the Antarctic Plateau as a infrared calibration target for AIRS validation.
  - Uniform surface with high infrared emissivity
  - Extremely thin atmosphere
    - Atmospheric correction is small.
    - TOA clear-sky, window radiances are nearly equal to emission from snow surface.

The Validation Concept

- Initial focus will be on comparing ground-based measurements of upwelling radiance over the Antarctic Plateau with level 1B radiances for AIRS.

- Will also provide product validation for:
  - T and H_2O retrievals in lowest 3 km
    - Feltz and Smith
  - Land-surface (snow) temperature
  - Spectral infrared emissivity
  - Cloud microphysical properties
    - Mahesh et al (2001) – infrared optical depth, effective particle radius

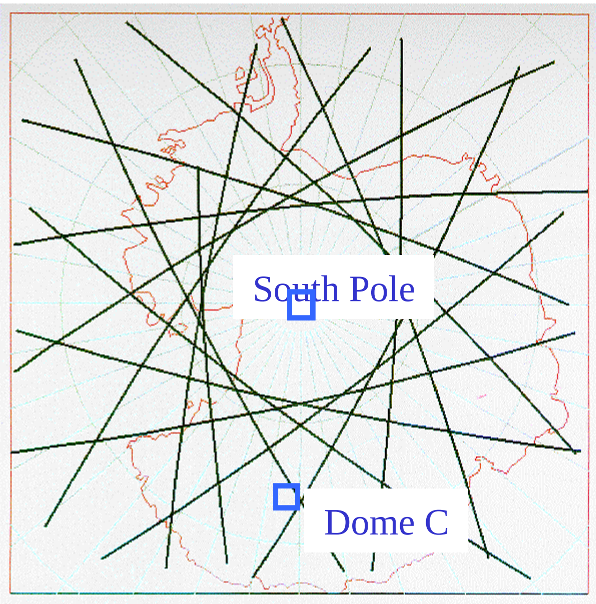
Location: Dome Concordia (74.5 S, 123.0 E)



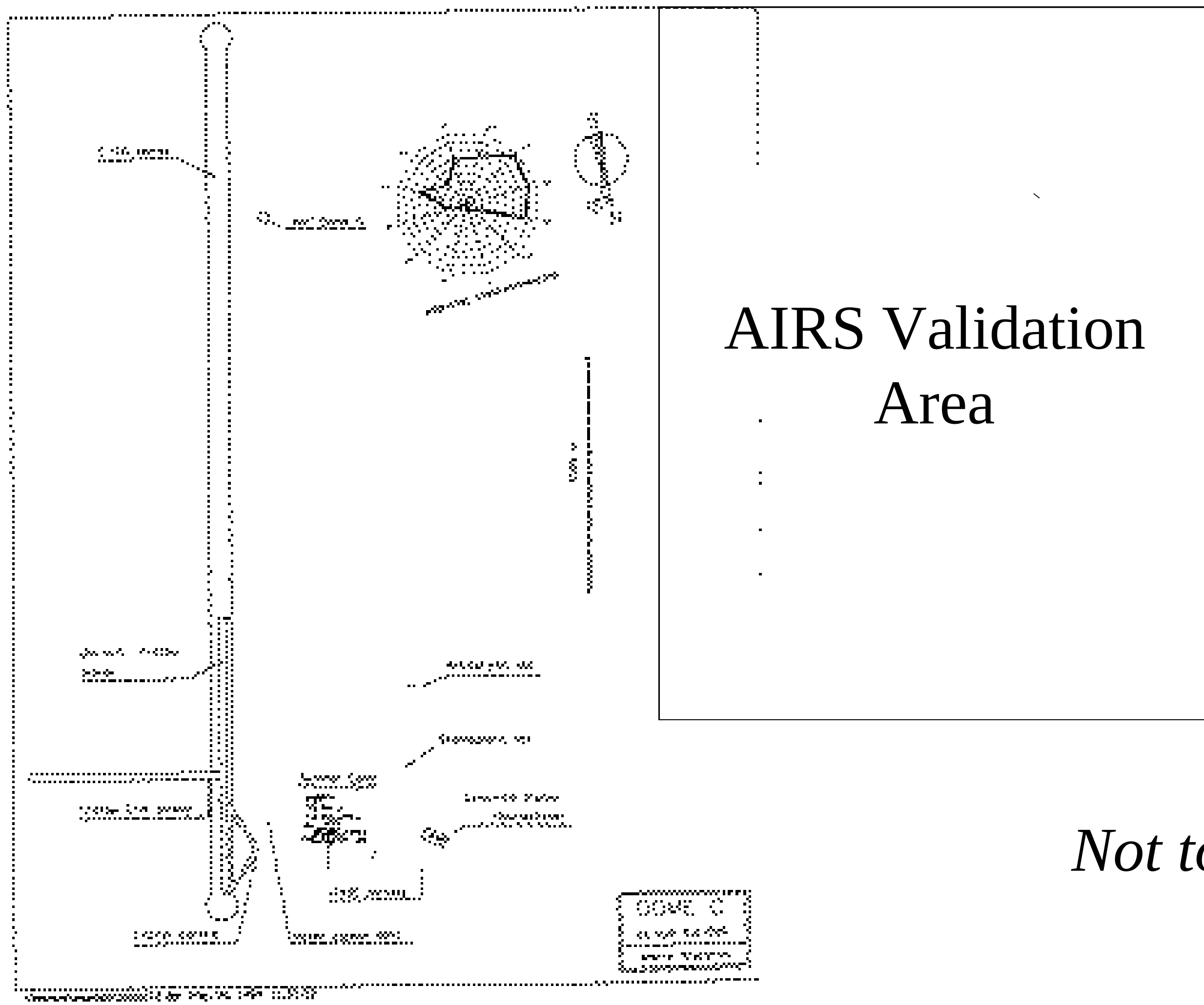
Map of Antarctic. Contours of elevation are shown, beginning at 2,500 meters. Locations mentioned in the text are indicated by symbols: Amery Ice Shelf (A), Byrd Station (B), Dome-C (C), Cape Denison (D), Filchner-Ronne Ice Shelf (F), Little America (L), Myrnyy (M), Pionerskaya (N), Plateau Station (P), Ross Ice Shelf (R), South Pole (S), Vostok (V), Mizuho (Z), Trans-Antarctic Mountains (^).

Location

- Dome Concordia
  - Station operated jointly by the French and Italian Antarctic Programs.
  - High elevation: 3280 meters (~10,500 ft.)
  - Multiple overpasses by Aqua everyday
  - High frequency of clear skies
  - Undisturbed snow, upwind of station



Location
(Dome C site map)



Not to scale!

Timing of Experiment

- Constrained by austral summer field season (Dec – Jan)

  – 24 March 2002 – Current launch date of EOS AQUA

– Launch +60 to +180	Basic Field Validation
– Launch +90 to +180	Cloud Clearing Validation
– Launch +150 to +330	Retrieved T, q Validation
– Launch +240 to …	Extended Validation Activities

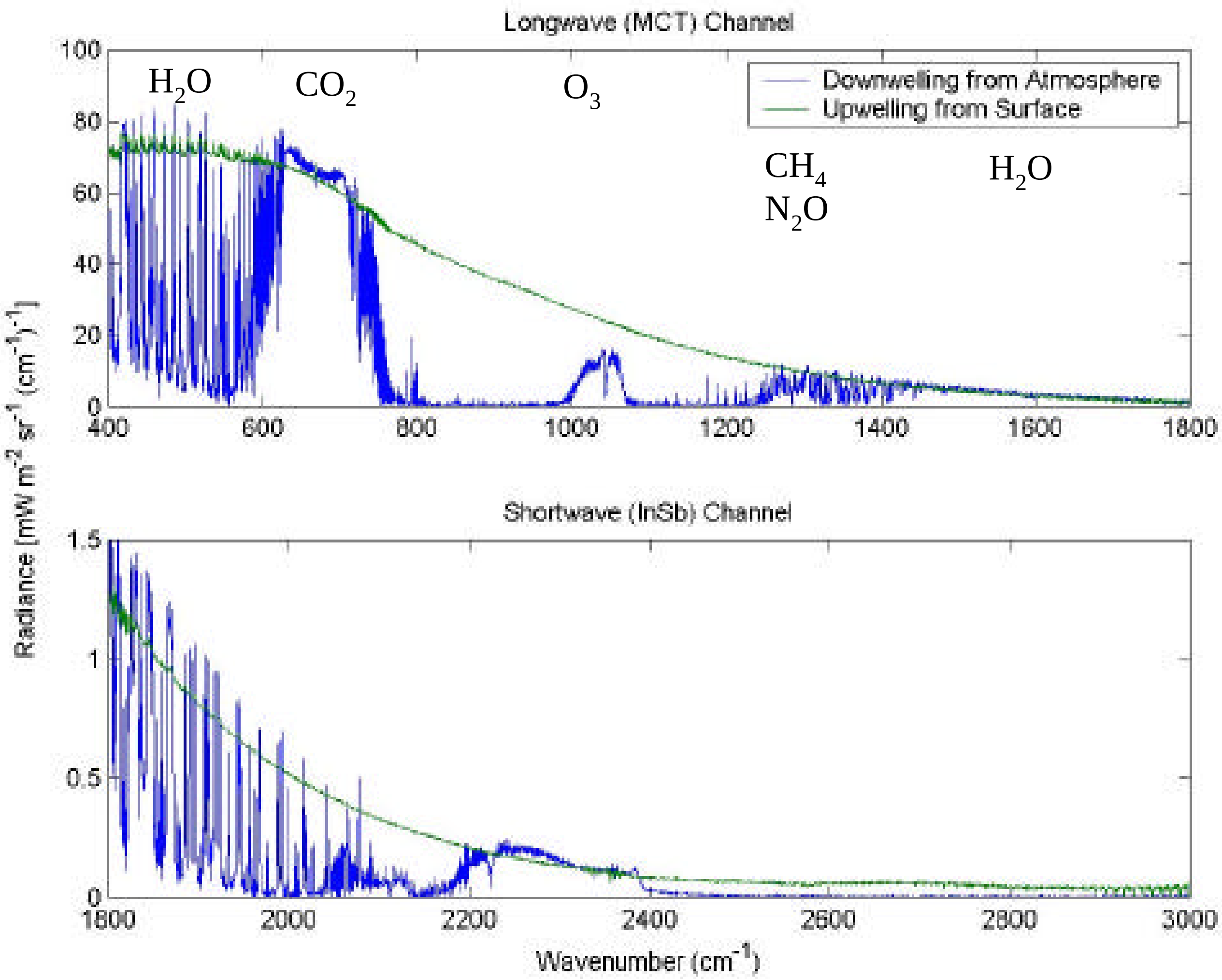
- Dome C validation experiment is scheduled to begin on 27 December 2002, which is currently Launch + 278 (Launch + 9 months).

Validation Instruments

- **PAERI – Polar Atmospheric Emitted Radiance Interferometer (Von P. Walden, University of Idaho)**
  - Similar to a Marine AERI
  - Deployed from 6-m tower
  - Ability to measure in the direction of AIRS ground and sky view angles
  - Extended-range detector
    - 24 microns
  - Used at South Pole in Summer 1999/2000 and Full-year of 2001.

Validation Instruments

- Sample PAERI spectra from South Pole Station, 30 Jan 2000



Total Column Water Vapor = 1 mm

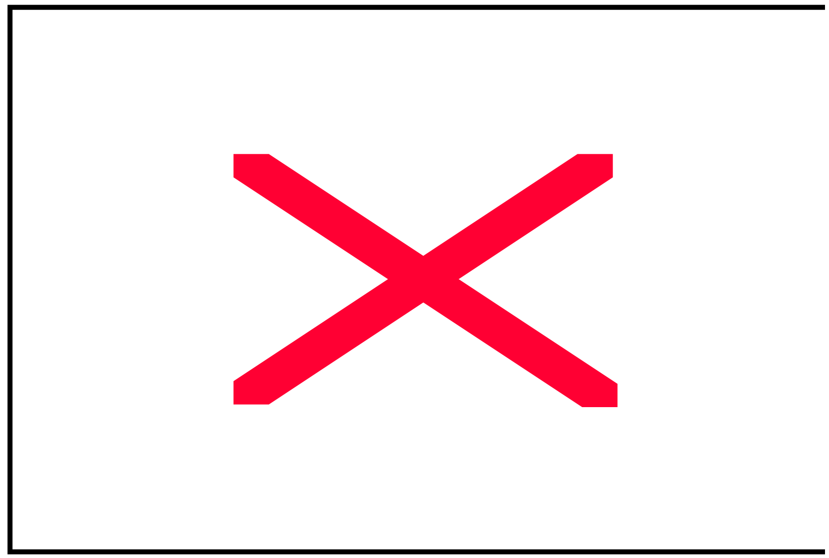
Validation Instruments

- **IRT - Infrared Radiometric Thermometer (Bob Stone, NOAA-CMDL)**

  – Based on a Heimann KT-19

  – Narrowband radiometer with spectral range from 8 – 12 microns

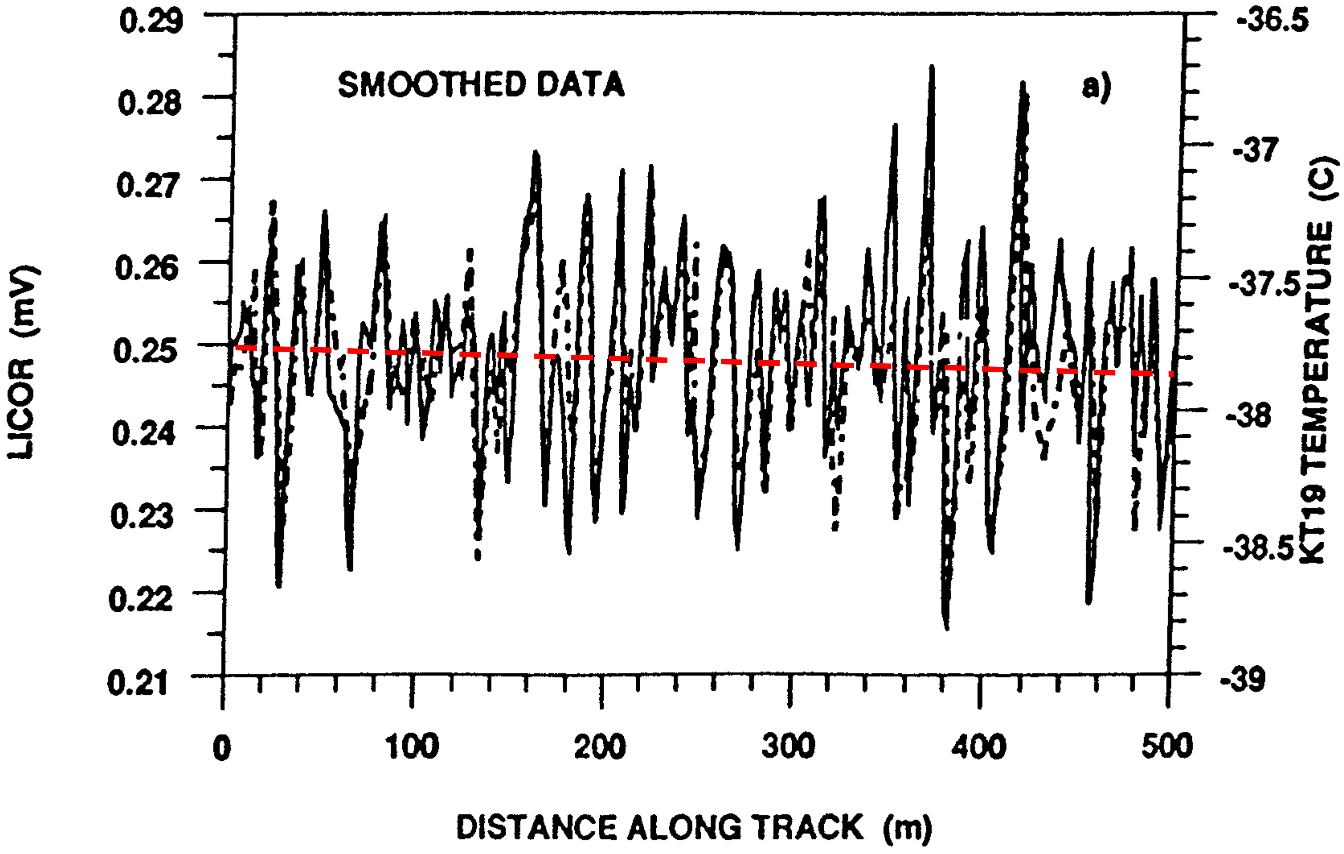
  – Used during SHEBA



  – Will be calibrated relatively to the PAERI in the field for each validation measurement.

Validation Instruments

- Sample IRT data from South Pole Station, 1993



Validation Instruments

- **NCAR GPS/Loran Atmospheric Sounding System (GLASS)**
  - Radiosondes for atmospheric characterization (P, T, H2O)
- **Ground-based Global Positioning System (GPS)**
  - For measuring total column water vapor
  - Used to constrain radiosonde humidity profiles
- **NASA Micropulse Lidar**
  - Detection of clear-sky conditions; avoid sub-visible ice clouds

Sample Validation Experiment

```
                  Hours
4         5         6         7         8
     *              *              *

             Aqua Overpasses


     |-------------------->        |----->
            Radiosonde Launches


|---------------------------------------|
           PAERI Observations


|---------------------------------------|
    IRT measurements behind snowmobile
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- Set up automated PAERI obs of upwelling spectra.
  - Observing downwelling spectra before and after experiment.
- Should be able to cover tens of kilometers with IRT.

Measurements for AIRS Validation

$$\boxed{L_{up} = [\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}] * \tau + E}$$

where L_{up} - upwelling radiance at instrument
ε_s - surface snow emissivity
B - Planck radiance
T_s - surface skin temperature
L_{down} - downwelling radiance at sfc
τ - atmospheric transmission
E - atmospheric emission from sfc to obs

Notes:

1) All variables are functions of frequency except T_s.
2) All functions are also functions of viewing angle except B and T_s.

Measurement Methodology #1

1) Measure $[\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}]$ and L_{down} at the AIRS view angle with the ground-based PAERI.

   Measure the spatial variability of T_s using the IRT; check spatial variability threshold.

2) Measure sonde information (T, H_2O) and assemble model atmosphere.

3) Compare L_{down} with radiative transfer calculations. Adjust model atmosphere, if necessary.

4) Calculate τ and E using model atmosphere.

5) Calculate the upwelling radiance at TOA (L_{up}) using measured surface emission and model atmosphere.

6) Convolve L_{up} at TOA with AIRS SRFs.

Measurement Methodology #2

1) Measure $[\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}]$ and L_{down} at the AIRS view angle with the ground-based PAERI.

   Measure the spatial variability of T_s using the IRT; check spatial variability threshold.

* 2) Retrieve T_s and ε from the downlooking PAERI measurement.

3) Measure sonde information (T, H2O) and assemble model atmosphere.

4) Calculate the upwelling radiance (monochromatically) at TOA (L_{up}) using retrieved values of T_s and ε, in conjunction with the model atmosphere.

5) Convolve L_{up} at TOA with AIRS SRFs.

Sources of Uncertainty in L_{up} at TOA

- $\sigma([\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}])$ not to exceed 0.06 K at 240 K
  - Should be similar for MAERI for SST
  - Based on NIST standard

- Uncertainties in atmospheric correction are small (τ, E). Sensitivity studies show that our uncertainty in knowledge of the atmosphere is negligible; less than 0.01 K at the most transparent frequencies
  - 862, 902, 960, 1132, 2616 cm^{-1}
  - main contributors are uncertainties in T and H2O profiles

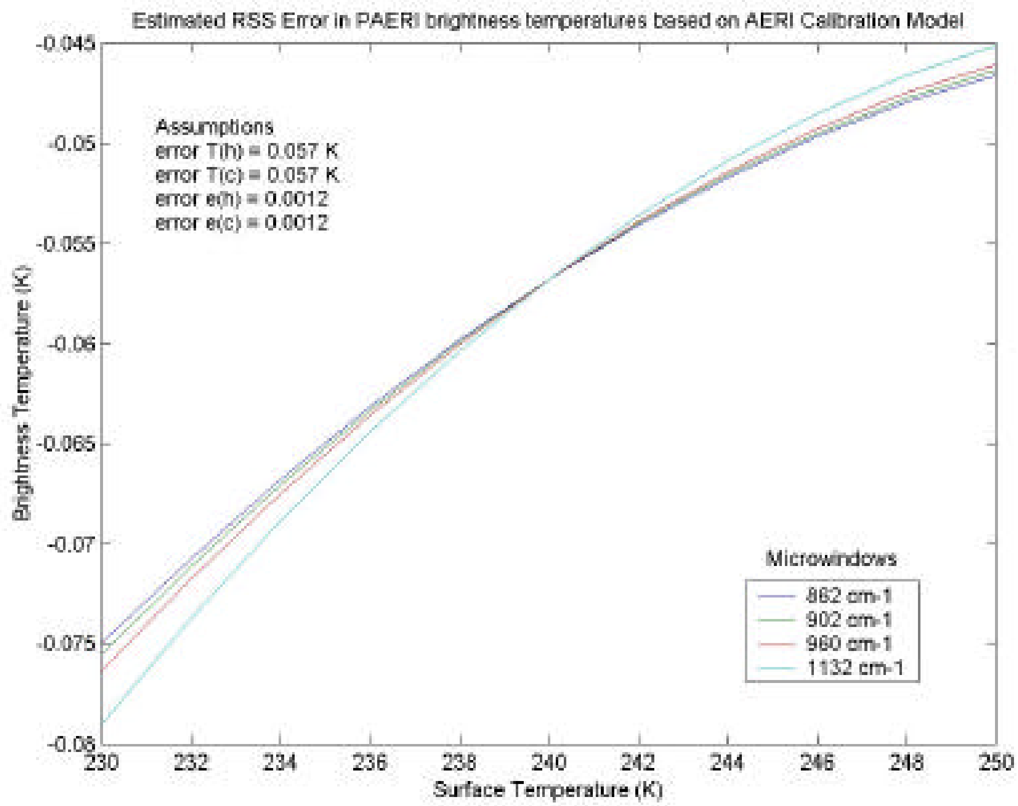
- Other issues:
  - spatial variability of T_s
  - spatial variability of ε; should be small
  - effect of “clear-air” ice crystals on τ and E

$\sigma([\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}])$

- Using U. Wisconsin AERI calibration model

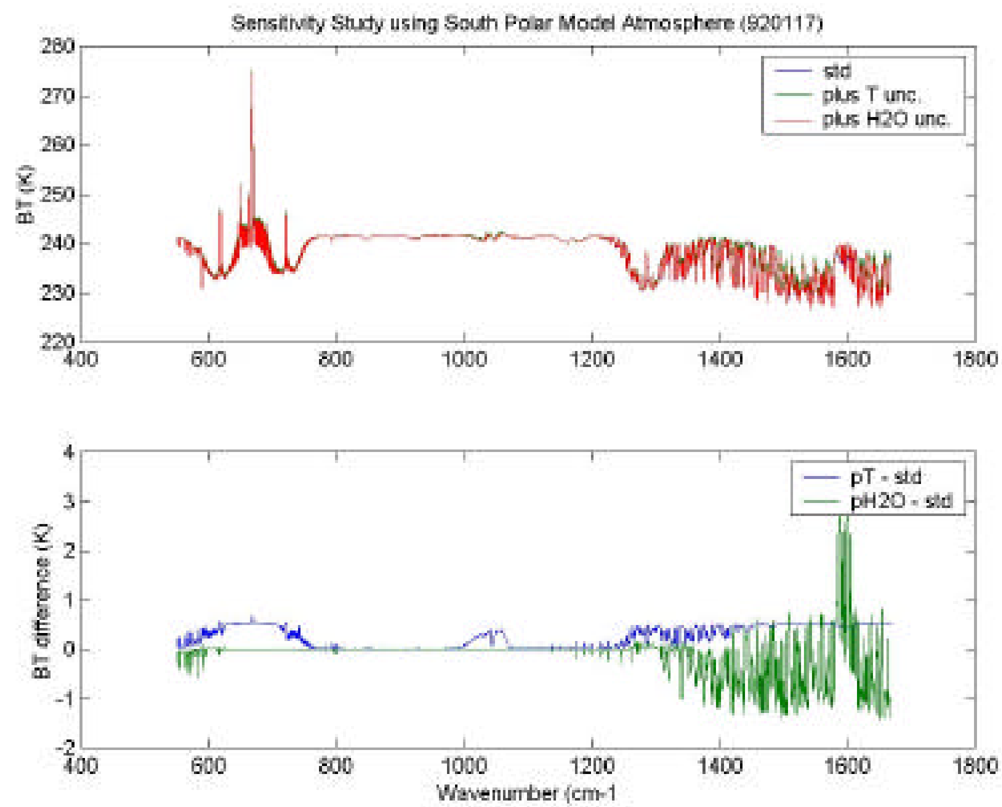
$$[\varepsilon_s * B(T_s) + (1-\varepsilon_s) * L_{down}] = \mathrm{Re}[(C_s - C_c) / (C_h - C_c)] * (B_h - B_c) + B_c$$

$$B_h = \varepsilon_h * B(T_h) - (1-\varepsilon_h) * B(T_{reflected})$$



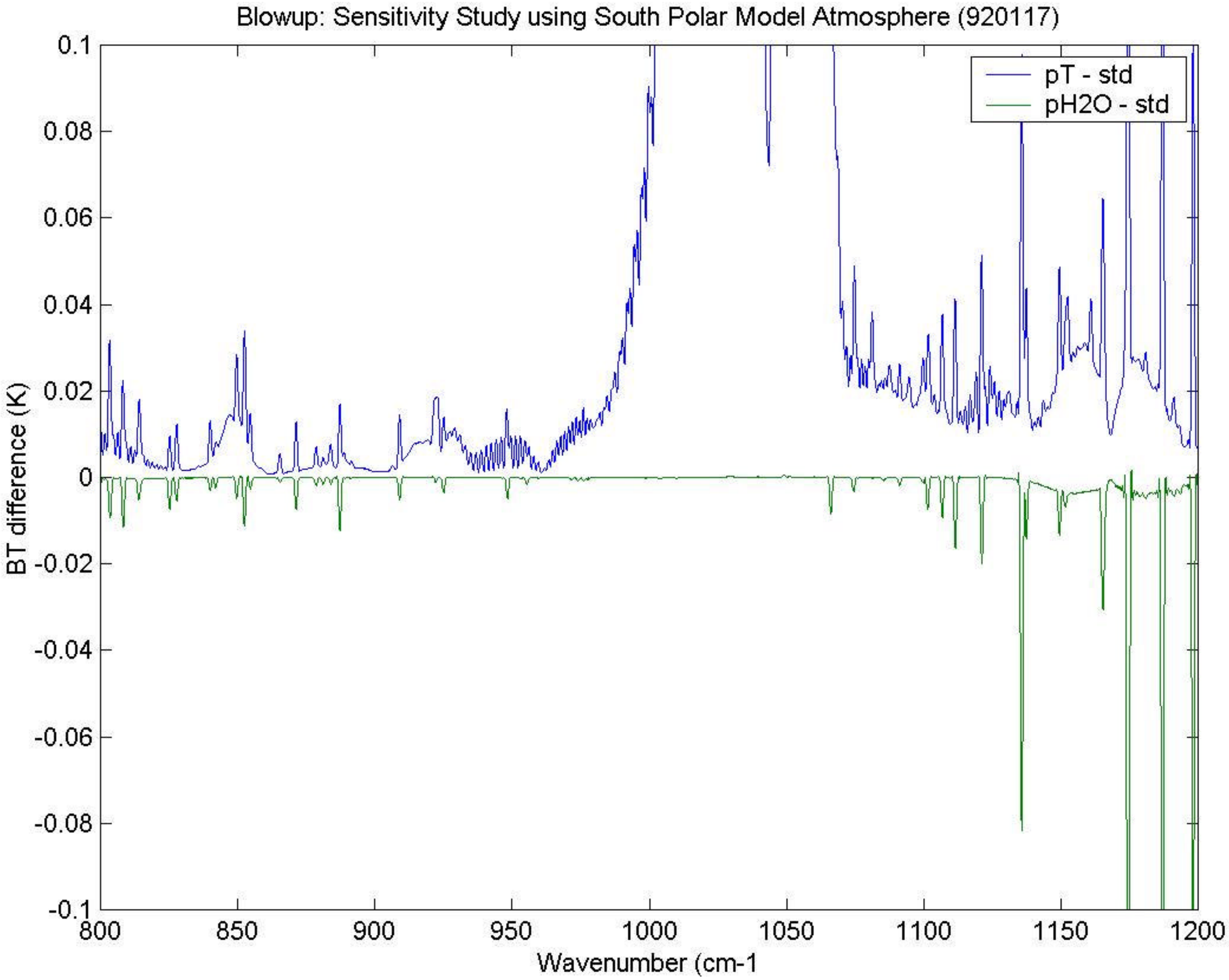
Antarctic Atmosphere Sensitivity Studies

- Simulations with LBLRTM using model atmospheres (with uncertainties) from South Pole 1992 (Walden et al, 1998).



Antarctic Atmosphere Sensitivity Studies

- Blowup of sensitivity in the 800-1200-cm^{-1} window region



Conclusions

- Antarctic validation activities begin at Launch + 9 months
  - Complement to MAERI and BBAERI activities
  - Low radiance and humidity
- Level-1B radiances
  - In-field analysis
  - Concentrate on microwindows
  - *Ultimate goal*: Timely TOA comparisons
- Level 2 Products
  - T_s, ε_s - In-field analysis, based on current work with South Pole data
  - T(z), H2O(z)
  - Cloud microphysical properties